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The effects of attention deficit/hyperactivity disorder on fixations and saccades during a simulated driving task

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THE EFFECTS OF ATTENTION DEFICIT/HYPERACTIVITY DISORDER ON
FIXATIONS AND SACCADDES DURING A SIMULATED DRIVING TASK

by

JESSICA R. MICHAELIS

A Thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Psychology
in the College of Sciences
and in The Burnett Honors College
at the University of Central Florida
Orlando, Florida

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Thesis Chair: Janan Al-Awar Smither

ABSTRACT

Individuals who have Attention Deficit/Hyperactivity Disorder (ADHD) experience adverse effects relating to driving; in addition, they experience deficits in scanning ability (Barkely et.al, 1996; Fischer et al., 2007; Munoz et al., 2003; Naja-Raja et al., 2007). The present study examined the effects of ADHD on eye tracking while driving. Ten participants consisting of both ADHD and individuals who do not have ADHD were included in this study. It was hypothesized that individuals who have ADHD will make more saccadic eye movements and thus shorter fixations than individuals who do not have ADHD. Furthermore, it was hypothesized that despite the fact that individuals who have ADHD will make more saccadic eye movements than individuals without ADHD, those individuals with ADHD will commit more traffic violations including collisions compared to individuals who do not have such a diagnosis. Findings indicated that hypothesis one was not supported by the data, whereas hypothesis two was supported in that ADHD individuals' had more collisions and committed more traffic violations than the Control group. Additionally, upon conducting a Chi Square test for independence, a significant difference was found in the spatial distributions of the fixations between the ADHD and Control groups. The findings of this study could help better understand the factors involved in ADHD driving and could be used to train individuals with ADHD to become more aware of their surroundings and driving habits and thus become safer drivers.

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CHAPTER ONE: INTRODUCTION

With automotive collisions accounting for 24.4% of American fatalities annually, research exploring ways of improving driving safety is more important than ever (Heron et al., 2009). Driving is an acquired skill that requires attention to detail, including perception of road hazards, preemptive avoidance of risky situations, and knowledge of all traffic laws among others (Committee on Injury, Violence, and Poison Prevention & Committee on Adolescence, 2006). Additionally, individuals who have ADHD have deficits in response inhibition. This inability to inhibit unwanted fixations and saccades can be dangerous when driving. According to Daigneault, Joly and Frigon, (2002) driving a motor vehicle requires the ability to sustain visual attention as well as to inhibition distractors in the visual field. For the average American, the acquisition of these skills comes fairly easily; however, in the past two decades research has shown this may not be true for individuals who have Attention Deficit/Hyperactivity Disorder. Studying saccades and fixations of individuals who have ADHD while driving, could provide insight into why they have difficulties acquiring and/or displaying these skills.

CHAPTER TWO: LITERATURE REVIEW

Attention Deficit/Hyperactivity Disorder

Attention Deficit/Hyperactivity Disorder (ADHD) is a behavioral disorder characterized by persistent inattention, hyperactivity, and/or impulsiveness compared to peers of the same developmental level (American Psychiatric Association [DSM-IV-TR], 2000). ADHD originates in early childhood affecting up to 5% to 8 % of children. Of these children, 66% will still be clinically diagnosable in adulthood (Barkley et al., 2002; Briggs-Gowan et al., 2000). The symptoms as characterized by the disorder are applicable to driving performance. Thus, it is reasonable to hypothesize that individuals who have ADHD might display riskier driving habits than individuals who don't have such a diagnosis. Some research has found this was shown to be the case (Barkley et al., 1993; Barkely et al., 1996; Fischer et al., 2007; Heron et al., 2009; Naja-Raja et al., 2007).

Driving Reports and ADHD

One study on driving related risks and outcomes related to ADHD found, through self-report and parent report surveys, that adolescents and young adults who have ADHD had a greater likelihood for revocation or suspension of their licenses, incurred four times more traffic citations most often as a result of speeding, and were about four times more likely to be a driver involved in a collision (Barkley et al., 1993). In addition, parental reports on driving skills showed that individuals who had ADHD displayed riskier driving habits (Barkley et al., 1993). Naja-Raja et al. (2007) conducted a similar study. These researchers found that both males and females between 15 and 18 years old who had ADHD and/or a Conduct Disorder committed

more driving offenses than individuals without these disorders, as shown by both in the self-report and official driving records. Furthermore, they found that females who had ADHD were involved in significantly more automobile crashes compared to other females in all other groups studied. However it is unknown, whether or not the symptoms of ADHD explain the collisions or violations that occurred. Unfortunately, the aforementioned studies lacked measures of actual or simulated driving performance.

Driving Simulator Research and ADHD

The assessment of simulated driving performance in those who have ADHD is limited. The studies that have been conducted thus far further corroborate self-reports and official driving records, such that drivers with ADHD exhibit more driving impairments, such as speeding and collisions, compared to those individuals in control groups. Barkley, Murphey, and Kwasnik (1996) as well as Fischer, Barkley, Smallish, and Fletcher (2007) showed that individuals who have ADHD had incurred significantly more collisions while using a driving simulator. Additionally, they had greater steering variability (Fischer et al., 2007) as well as poorer steering control (Barkely et al., 1996). All the information presented thus far has shown that individuals who have ADHD have higher risks associated with driving a motor vehicle.

Visual Attention and ADHD

These risks may be due to the fact that driving a motor vehicle requires sustained visual attention as well as to inhibition distractors in the visual field in order to focus on the task (Daigneault, Joly, & Frigon, 2002). Dingus, Klauer, Neale, Petersen, Lee, and Sudweeks (2006)

conducted a study on attention and driving and found that inattention is the greatest contributing factor of automobile crashes. In addition, Strayer and Johnston's (2001) study of driving and conversing on a cell phone further corroborates the importance of attention. Strayer and Johnston (2001) found a significant increase in the failure to perceive a traffic signal change while on a cell phone and also a delay in responses to those that were not noticed. Thus, attentiveness while driving is a major safety concern. For individuals who have ADHD and experience attentional deficits, such concerns may be heightened.

Eye Tracking

One way in which researchers are able to study attentional performance is through the use of an eye tracker (Duchowski, 2002; Rayner, Miller, & Rotello, 2008). Eye trackers record eye movements and map them to objects in the visual field. Hoffman and Subramanian (1995) found that individuals are unable to fix their eyes in one area of a scene and attend to another location simultaneously. Therefore, eye tracking is useful in studying attention by showing where drivers are looking, and correspondingly where they are not. Furthermore, the use of eye tracking while driving is shown to be a crucial tool in assessing driving performance because of its ability to record where individuals are visually attending, especially in potentially dangerous situations (Chapman & Underwood, 1999).

Driving and Eye Tracking

One way to assess scanning with an eye tracker is to monitor individuals' saccades and fixations. Saccades, as defined by Munoz, Armstrong, Hampton and Moore (2003), are "rapid

eye movements used to move the high acuity fovea of the retina to visual targets for detailed visual analysis.” (p. 503). Typically, when an individual is not making a saccade he/she is fixating on something. A fixation is when an individual maintains a steady gaze on an object or in a specific location. Furthermore, individuals can make smooth pursuit eye movements. These eye movements are sometimes used to follow a moving object; however, we do not currently have the technology to monitor such movements. Previous research on scanning and driving varies from study to study, but one aspect that is certain is that scan paths differ according to experience and as a result of being distracted (Harbluk, Noy, Trbovich, & Eizenman, 2007; Underwood et al., 2005; Victor et al., 2005). Underwood et al. (2005) found that novice drivers fixated significantly more far in front of the vehicle. Furthermore, they found that experienced drivers allocated more of their visual attention on potential hazards to their left and right while they used their periphery to see potential hazards in front of the vehicle. Additionally, Harbluk et al. (2007) found that engaging in a conversation on a hands-free cell phone impacted the driver’s visual scanning, resulting in fewer peripheral scans. One more factor to take into consideration when discussing distraction is inattention blindness, which occurs when an individual looks directly at an object but does not notice it (Strayer & Drews, 2007).

Eye Tracking and ADHD

Despite the fact that individuals who have ADHD experience more adverse events while driving such as traffic citations and collisions, no research has been conducted that has used an eye tracker to assess scanning and fixations in individuals while driving in a simulator. However, research on scanning and ADHD has shown that individuals who have ADHD have deficits in

response inhibition. As a result, these individuals are less able to inhibit unwanted saccades and have a decreased ability to govern the amount and duration of fixations made (Karatekin & Asarnow, 1999; Mostofsky, Lasker, Cutting, Denckla, & Zee, 2001; Munoz, Armstrong, Hampton, & Moore, 2003; Ross, Harris, Olincy, & Radant, 2000). Additionally, Gould, Bastain, Israel, Hommer, and Castellanos (2001) found that individuals who have ADHD made significantly more large saccades, which was defined as eye movements greater than four degrees away from the object of fixation, during a visual fixation task, regardless of gender, than the control group.

Based on the information presented thus far, we hypothesized that individuals who have ADHD will make more eye movements and have shorter fixations than individuals who do not have ADHD while driving in the simulator. Furthermore, we hypothesized that those individuals with ADHD will commit more traffic violations including collisions compared to the individuals not diagnosed with ADHD individuals.

CHAPTER THREE: METHODOLOGY

Participants

The participants were comprised of 10 individuals, seven males and three females, from a Southeastern University and consisted of five individuals who did not have ADHD as well as five individuals registered with the Student Disability Services Office who had ADHD. A letter that provided information about this study was sent by the Student Disability Office to all registered individuals who had ADHD asking them to contact the principal investigator if they were interested in participating. Due to the fact that individuals who had ADHD came from the Student Disability Office, it was guaranteed that rigorous testing for ADHD would have been completed by a qualified clinical psychologist within the last three years. Within the ADHD group, only those participants who were not currently taking any medications for the disorder were used due to the fact that many studies have shown individuals taking stimulant medication for ADHD significantly improved their driving abilities (Barkley, Murphy, O'Connell, & Connor, 2005; Cox, Merkel, Kovatchev, & Seward, 2000; Cox, Humphry, Merkel, Penberthy, & Kovatchev, 2004). Non-ADHD participants volunteered to participate by responding to flyers that were posted on campus or signing up on Sona Systems. All participants were compensated either by credit through Sona Systems or monetarily in the amount of five dollars. Furthermore, participants were directed not to wear eye makeup of any kind during the time of their participation, because it interfered with the eye-tracker. In addition, they were required to have a valid driver's license, good vision, which was classified by at least having 20/40 vision with contacts or glasses, and not be prone to motion sickness based on the score of a motion history questionnaire.

Based on the demographics questionnaire, of the 10 individuals that completed the study five were Caucasian, two were Hispanic, one was Asian and one was African American and Caucasian. Additionally, based on their self-reports, the number of hours spent driving in a typical week ranged from 1 to 21 hours and number of years that they were able to legally drive ranged from 2 to 14 years. Furthermore, there were initially 12 participants, six in each group; however, two individuals were excluded from the study because they did not meet some of the criteria that are stated below.

Materials/Apparatus

A series of initial screening tools were implemented which consisted of the Motion History Questionnaire, the Simulator Sickness Questionnaire, an adult ADHD self-report symptom checklist (ASRS-v.1.1), the Driving Habits Questionnaire (DHQ), a demographics questionnaire, and a battery of vision tests. The Motion History Questionnaire (MHQ) designed by Kennedy, Fowlkes, Berbaum, and Lilienthal (1992) was comprised of an initial screening survey to assess whether an individual was susceptible to motion sickness. Additionally, the Simulator Sickness Questionnaire (SSQ) was utilized to assess participants' reported sickness level before and after the simulated drive (Kennedy, Berbaum, & Lilienthal, 1993). The Adult Self Report Symptom Checklist (ASRS-v.1.1) was created in association with Harvard Medical School by Kessler et al. (2005) for the World Health Organization and consisted of 18 items relating to symptoms of ADHD. The ASRS-v.1.1 was measured using a five point Likert scale including the following responses in order of appearance: Never, Rarely, Sometimes, Often, and Very Often. Additionally, individuals who had ADHD were not screened for a specific sub-type.

A modified version of the Driving Habits Questionnaire that was designed by Owsley, Stalvey, Wells, and Sloane (1999) was used in the study to assess participants' previous driving behaviors, such as driving frequency, collisions, and traffic violations. A demographics questionnaire included questions about participants' sex, race, and age. In addition to the aforementioned surveys, a battery of vision tests was conducted on an OPTEC machine and consisted of far and near visual acuity (i.e. Snellen acuity), color vision, and contrast sensitivity. Furthermore, upon completion and passing of the aforementioned surveys and tests, both a driving simulator and an I SCAN eye tracker were utilized.



Figure 1: City Car Driving Motorway Scenario

Multisoft's English based simulated driving software, City Car Driving version 1.0, was used in conjunction with a Microsoft Sidewinder steering wheel and pedals which were setup on a desk facing the projected scenario, which had a resolution of 1600×1024 and refresh rate of 60 Hz. Furthermore, this simulator software provided an array of different driving scenarios to choose from which included city and motorway. The aforementioned scenarios were adaptable for time of day, weather conditions, and amount of traffic. The simulator software also measured driving performance, including driving speed, lane deviations, and collisions. A daytime modern

city scenario and motorway scenario with a moderate amount of traffic was used from the simulator's preexisting databank.

In addition to monitoring participants' driving behaviors, an ISCAN ETL-500 head mounted eye tracker was utilized to monitor eye movements. The eye tracker was comprised of two cameras, one that monitored what the participants were looking at and the other monitored pupil and corneal reflection via the reflection of infrared red light off of the participants' eyes.

After calibration, this information then was recorded using a dual screen Sony cassette recorder. These data were analyzed using data preprocessing software that numerically showed



Figure 2: I SCAN ETL-500 Eye Tracker

the number, duration, and location of participants' fixations and saccades. The data from the eye tracker was saved as the two dimensional (x, y) coordinates of the gaze location in the scene. The gaze velocity was derived from the 2D spatial data from the Pythagorean method which was sampled at 60Hz intervals from the eye tracker. In addition, the eye velocity data was filtered using a dual-pass, low pass, Butterworth filter with a 5Hz cut off frequency. Fixations were determined when the eye velocity dropped below 3% of the peak eye velocity during a given trial and when the eye velocity stayed below this criterion level for at least 10 frames (.167 seconds). Furthermore, saccade durations were inferred from the durations of the intervals between fixation points. Fixation points were located in the scene based on the 2D spatial data. For each fixation, an average fixation location was determined based on the geometric average of the 2D data for the entire duration of the fixation. The fixation locations then were localized based on a

grid overlaid on the screen, defined left, center, and right. Participants viewed the image from a distance of 182.88cm. The height of the image was 157.48cm, subtending a visual angle of 46.59 degrees. Furthermore, the width of the image was 213.36cm, subtending a visual angle of 60.51 degrees.

Procedure

Individuals who were not diagnosed with ADHD volunteered to participate via flyers posted on campus by contacting the researcher via email or telephone. All individuals who had ADHD contacted the researcher via email or telephone by responding to an email sent out by the Student Disabilities Office. All of the participants (ADHD & Controls) who had a current driver's license and who were at least 18 years of age could volunteer to participate in the study. The Motion History Questionnaire designed by Kennedy et al. (1992) was utilized as a preliminary screening tool to measure participants' proneness to motion sickness and was administered to all prospective participants via telephone before coming in to see if they were eligible to participate, so that participants' time was not unnecessarily wasted. No individuals failed the MHQ and had to be ruled out of the study. Upon receiving a passing score, each of the participants proceeded individually to the Technology and Aging laboratory at prescheduled times. Participants then were presented with and reviewed an informed consent document so that they were fully aware of what was expected and any risks that might have been associated with participating. Upon their consent the experimenter began conducting the preliminary screening measures. First, the participant was asked to fill out the Simulator Sickness Questionnaire (SSQ), an Adult ADHD Self Report Symptom Checklist (ASRS-v.1.1), and the Driving History

Questionnaire, both the SSQ and ASRS-v.1.1 was scored while the participant filled out the driving history questionnaire and the demographics questionnaire. Participants' near and far visual acuity, contrast sensitivity, and color vision were then tested using the OPTEC. Further participation in this study required the participant to have at least 20/40 vision with glasses or contacts if needed, normal contrast sensitivity, as well as normal color vision. If the participants did not meet one of these criteria, they were excluded from the study.

Secondly, upon completion all of the prescreening surveys and tests, participants were escorted to the simulation room. Participants then were asked to sit in the driver's seat, at which time they were briefed on putting on the eye tracker and the calibration of the eye tracker. Once the eye tracker was placed on participant's heads, the experimenter began the calibration process. This process consisted of looking at a total of five cross hairs individually, which lasted about 5 to 10 minutes. The calibration then was checked to make sure that it was accurate. If it was not accurate, a second calibration was necessary. After calibration, the participants were given three minute driving in a city scenario to become comfortable driving on the simulator. A short one minute break then ensued. Finally, the experiment commenced, and all of the eye tracking and driving data were recorded from this three minute motorway driving session. Before which, the participants were reminded that they could stop at any time, especially if they were feeling sick, with no penalty. In addition, participants were asked to follow all traffic rules and were informed that the speed limit in the city scenario was 70kph and 90kph (55.93 mph) in the motorway scenario for the duration of their drive. The experimenter instructed the participants to release the parking brake and proceed to drive as they normally would. After participants drove for a specified amount of time, they participant were given another SSQ to assess the level of motion

sickness, if any, that they were experiencing. The participants then were debriefed on the study and were free to go if they were not experiencing any motion sickness. If participants were experiencing motion sickness, they were asked to come back to the initial room until they felt better. These participants would have been provided crackers and drinks, however, no participants experienced motion sickness and they all departed after the study concluded.

CHAPTER FOUR: RESULTS

An independent samples t-test was conducted to compare the duration of fixations made during a simulated motorway driving scenario in individuals who have ADHD and those who do not (Control). No significant difference was found in the duration of fixations made for the ADHD group ($M = 1.48$, $SD = 50.53$) and the Control group ($M = 1.11$, $SD = 5.25$), $t(8) = 1.07$, $p > .05$. This finding indicated that participants in the ADHD and control groups did not differ in how long they looked at objects while driving in the simulation (see Figure 3).

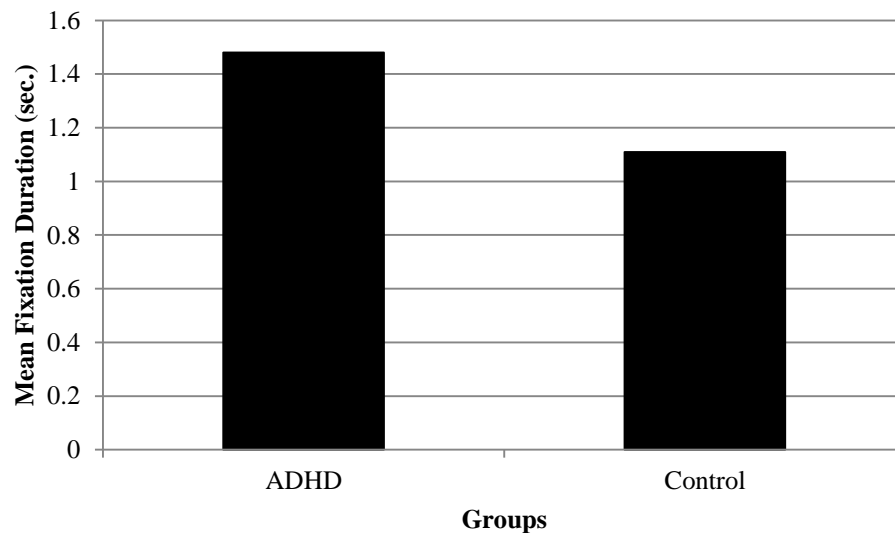


Figure 3: Mean Fixation Duration

Another independent samples t-test was conducted to compare the total number of fixations made during the simulated motorway driving scenario in the ADHD and Control groups. No significant difference was found in the numbers of fixations made for the ADHD group ($M = 115.20$, $SD = 40.42$) and the Control group ($M = 127.00$, $SD = 10.37$), $t(8) = -.63$, $p >$

.05 (see Figure 4), This finding suggested that the two groups did not differ in the amount of times that they focused on objects during the simulated drive.

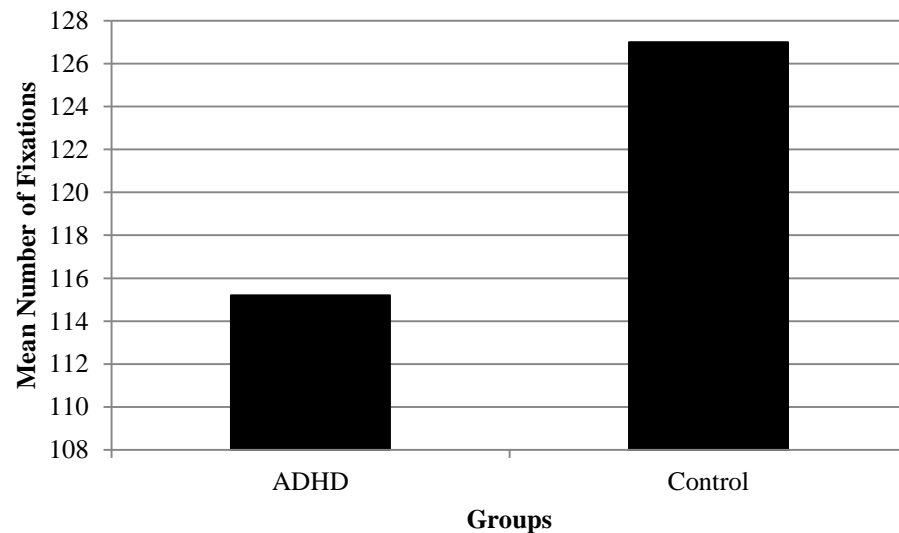


Figure 4: Mean Number of Fixations

Although no significant differences were found for both the duration as well as the number of fixations made, a Chi Square test for independence suggested that there was a significant difference in the spatial distributions of the fixations between the ADHD and Control groups, $\chi^2(2, N = 10) = 26.22, p < .01$, Cramer's $V = .15$ (see Figure 5). Specifically, there was an overall tendency to neglect to look at the right side of the screen in both groups; however, the ADHD group looked to the right significantly less than the Control group.

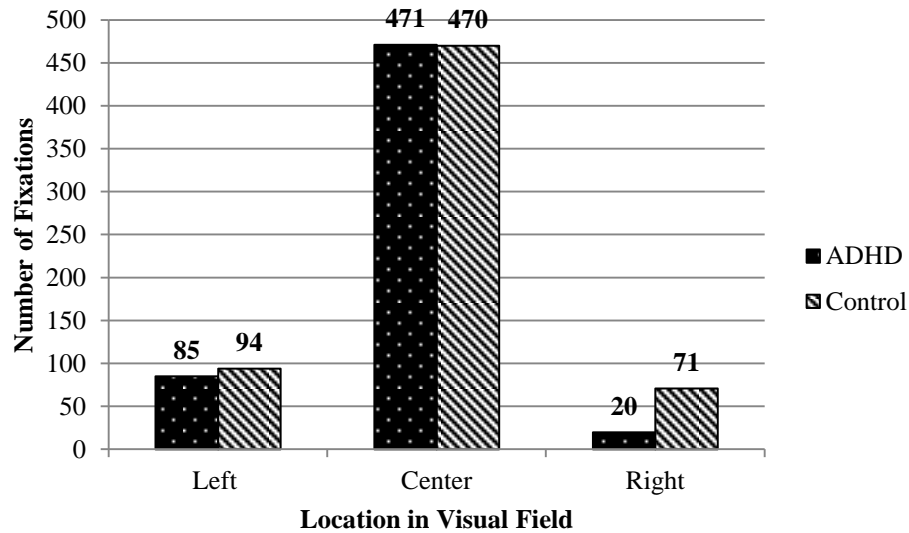


Figure 5: Location of Fixations in the Visual Field

Furthermore, a Chi Square test for goodness of fit was performed to analyze the difference in the number of unsignaled lane deviations in both of the groups. The results indicated that there was a significant difference in unsignaled lane deviations made by the ADHD and Control groups $\chi^2 (1, N = 10) = 5, p < .05$ (see Figure 6). This result indicated that those in the ADHD group committed more unsignaled lane deviations than those in the control group.

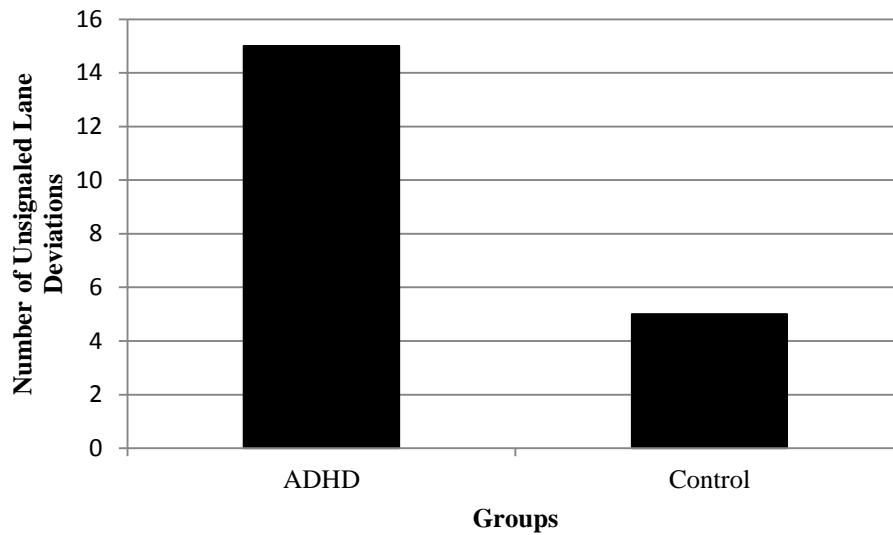


Figure 6: Number of Unsignaled Lane Deviations

Finally, because collisions were a rare occurrence, there was no statistical test to analyze the difference in accidents in the two groups. In total, four accidents were observed, all of which were committed by individuals in the ADHD group.

CHAPTER FIVE: DISCUSSION

The purpose of this study was to examine the effects of Attention Deficit Hyperactivity Disorder (ADHD) on saccades and fixations during a simulated motorway drive. It was hypothesized that individuals who have ADHD would make more saccadic eye movements and thus shorter fixations than individuals who were not diagnosed with ADHD. Furthermore, it was hypothesized that, despite the fact that individuals who have ADHD make more saccadic eye movements than individuals without ADHD, those individuals with ADHD would commit more traffic violations, including collisions, compared to individuals who do not have ADHD. The first hypothesis was not supported by the results. Results showed that both those in the ADHD and Control groups did not significantly differ in the number of fixations made, and therefore, did not differ in number of saccades made as one is the inverse of the other. Furthermore, based on the assumption of the first hypothesis, it was assumed that with the shorter fixation duration of the ADHD group would result in the ADHD group having more traffic violations and collisions. Despite the fact that the first hypothesis was not supported by the data, a significant result was found for number of unsignaled lane deviations. Additionally, the ADHD group was involved in four traffic collisions, whereas the Control group had no collisions. These data support previous studies, which suggested that individuals with ADHD are involved in more collisions and incur more traffic violations than individuals who are non-clinical (Barkley et al., 1993; Naja-Raja et al., 2007).

Despite the fact that no significant differences were found for both the duration and the number of fixations made, a Chi Square test for independence suggested that there was a significant difference in the spatial distributions of the fixations between those in ADHD and

Control groups. The data showed that those in the ADHD and the Control groups both neglected the right visual field; however, the control group made significantly more fixations in the right visual field than the ADHD group. Unfortunately, a small effect size was observed. Thus, indicating that although the data were significant at $p < .01$ level, a large difference in the right visual field was not observed. This small effect size may be due to the fact that a driving simulator was used for this study. Cho et al. (2002) showed that young individuals who have Attention Deficit Hyperactivity Disorder or other attention deficits experienced improved attention when placed in virtual reality environments. Additionally, the findings of this study may explain why saccadic movements as well as fixation durations did not differ between the ADHD and Control groups. Therefore, one may assume that the number and duration of saccades and fixations in general, as well as an increase in effect size for location of fixations, may be observed when driving with eye and head trackers in a real world environment rather than a simulated environment.

To further this research, the experimenter should obtain a larger, more diverse, population. Additionally, Barkely et al. (2006) found that there were no significant differences in driving knowledge between ADHD and Control groups but did find a significant difference in employing that knowledge while driving. Future research should be conducted using a controlled real world driving course to better understand the effects that ADHD has on saccades and fixations compared to the Control group. Additionally, Cho et al. (2002) found that individuals with attention deficits can learn through cognitive training to enhance their attention in virtual reality scenarios. This knowledge may then transfer to similar real life situations. The data acquired from the controlled real world driving course could help better our understanding of the

factors involved in ADHD driving and could be used to train individuals with ADHD by creating an exact virtual reality replica of the real world driving course. This virtual reality course would afford individuals who have ADHD a safe environment in which they could learn how to scan their surroundings for hazards appropriately while driving and how to correctly implement their knowledge of driving. Furthermore, this future research could be the key to improve the safety of ADHD individuals while driving in addition to the many other lives that are on the roadways each day.

APPENDIX A: MOTION HISTORY QUESTIONNAIRE

APPENDIX A: MOTION HISTORY QUESTIONNAIRE

MOTION HISTORY QUESTIONNAIRE

Developed by Robert S. Kennedy & colleagues under various projects. For additional information contact:
Robert S. Kennedy, RSK Assessments, Inc., 1040 Woodcock Road, Suite 227, Orlando, FL 32803 (407) 894-5090

Subject Number: _____ Date: _____

1. Approximately how many total flight hours do you have? _____ hours
2. How often would you say you get airsick?
Always _____ Frequently _____ Sometimes _____ Rarely _____ Never _____
3. a) How many total flight simulator hours? _____ Hours
b) How often have you been in a virtual reality device? _____ Times _____ Hours
4. How much experience have you had at sea aboard ships or boats?
Much _____ Some _____ Very Little _____ None _____
5. From your experience at sea, how often would you say you get seasick?
Always _____ Frequently _____ Sometimes _____ Rarely _____ Never _____
6. Have you ever been motion sick under any conditions other than the ones listed so far?
No _____ Yes _____ If so, under what conditions?
7. In general, how susceptible to motion sickness are you?
Extremely _____ Very _____ Moderately _____ Minimally _____ Not at all _____
8. Have you been nauseated FOR ANY REASON during the past eight weeks?
No _____ Yes _____ If yes, explain
9. When you were nauseated for any reason (including flu, alcohol, etc.), did you vomit?
Only with _____ Retch and finally vomited _____
Easily _____ difficulty _____ with great difficulty _____
10. If you vomited while experiencing motion sickness, did you:
a) Feel better and remain so?
b) Feel better temporarily, then vomit again?
c) Feel no better, but not vomit again?
d) Other - specify
11. If you were in an experiment where 50% of the subjects get sick, what do you think your chances of getting sick would be?
Almost certainly _____ Probably _____ Almost Probably _____ Certainly
would _____ would _____ would not _____ would not _____
12. Would you volunteer for an experiment where you knew that: (Please answer all three)
a) 50% of the subjects did get motion sick? Yes _____ No _____
b) 75% of the subjects did get motion sick? Yes _____ No _____
c) 85% of the subjects did get motion sick? Yes _____ No _____
13. Most people experience slight dizziness (not a result of motion) three to five times a year. The past year you have been dizzy:
More than this _____ The same as _____ Less than _____ Never dizzy _____
14. Have you ever had an ear illness or injury which was accompanied by dizziness and/or nausea? Yes _____ No _____

15. Listed below are a number of situations in which some people have reported motion sickness symptoms. In the space provided, check (a) your PREFERENCE for each activity (that is, how much you like to engage in that activity), and (b) any SYMPTOM(s) you may have experienced at any time, past or present.

SITUATIONS	PREFERENCE			SYMPTOMS												
	L I K E	N E U T R A L	D I S L I K E	V O M I T E D	N A U S E A	S T O M A C H A W A R E N E S S *	I N C R E A S E D S A L I V A T I O N	D I Z Z I N E S S	D R O W S I N E S S	S W E A T I N G	P A L L O R	V E R T I G O **	A W A R E N E S S O F B R E A T H I N G	H E A D A C H E	O T H E R S Y M P T O M S	N O N E
Aircraft																
Flight simulator																
Roller Coaster																
Merry-Go-Round																
Other carnival devices																
Automobiles																
Long train or bus trips																
Swings																
Hammocks																
Gymnastic Apparatus																
Roller / Ice Skating																
Elevators																
Cinerama or Wide-Screen Movies																
Motorcycles																

*Stomach awareness refers to a feeling of discomfort that is preliminary to nausea.

**Vertigo is experienced as loss of orientation with respect to vertical upright.

END OF MOTION HISTORY QUESTIONNAIRE

APPENDIX B: SIMULATOR SICKNESS QUESTIONNAIRE

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Simulator Sickness Questionnaire (SSQ)

Developed by Robert S. Kennedy & colleagues under various projects. For additional information contact:
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Subject Number: _____ Date: _____

PRE-EXPOSURE BACKGROUND INFORMATION

1. How long has it been since your last exposure in a simulator? _____ days
How long has it been since your last flight in an aircraft? _____ days
How long has it been since your last voyage at sea? _____ days
How long has it been since your last exposure in a virtual environment? _____ days
2. What other experience have you had recently in a device with unusual motion?

PRE-EXPOSURE PHYSIOLOGICAL STATUS INFORMATION

3. Are you in your usual state of fitness? (Circle one) YES NO
If not, please indicate the reason:
4. Have you been ill in the past week? (Circle one) YES NO
If "Yes", please indicate:
 - a) The nature of the illness (flu, cold, etc.):
 - b) Severity of the illness: Very _____ Very
Mild _____ Severe
 - c) Length of illness: _____ Hours / Days
 - d) Major symptoms:
 - e) Are you fully recovered? YES NO
5. How much alcohol have you consumed during the past 24 hours?
_____ 12 oz. cans/bottles of beer _____ ounces wine _____ ounces hard liquor
6. Please indicate all medication you have used in the past 24 hours. If none, check the first line:
 - a) NONE
 - b) Sedatives or tranquilizers
 - c) Aspirin, Tylenol, other analgesics
 - d) Anti-histamines
 - e) Decongestants
 - f) Other (specify):
7. a) How many hours of sleep did you get last night? _____ hours
b) Was this amount sufficient? (Circle one) YES NO
8. Please list any other comments regarding your present physical state which might affect your performance on our test battery.

Baseline (Pre) Exposure Symptom Checklist

Instructions: Please fill this out BEFORE you go into the virtual environment. Circle how much each symptom below is affecting you right now.

#	Symptom	Severity			
1.	General discomfort	None	Slight	Moderate	Severe
2.	Fatigue	None	Slight	Moderate	Severe
3.	Boredom	None	Slight	Moderate	Severe
4.	Drowsiness	None	Slight	Moderate	Severe
5.	Headache	None	Slight	Moderate	Severe
6.	Eye strain	None	Slight	Moderate	Severe
7.	Difficulty focusing	None	Slight	Moderate	Severe
8a.	Salivation increased	None	Slight	Moderate	Severe
8b.	Salivation decreased	None	Slight	Moderate	Severe
9.	Sweating	None	Slight	Moderate	Severe
10.	Nausea	None	Slight	Moderate	Severe
11.	Difficulty concentrating	None	Slight	Moderate	Severe
12.	Mental depression	None	Slight	Moderate	Severe
13.	"Fullness of the head"	None	Slight	Moderate	Severe
14.	Blurred Vision	None	Slight	Moderate	Severe
15a.	Dizziness with eyes open	None	Slight	Moderate	Severe
15b.	Dizziness with eyes closed	None	Slight	Moderate	Severe
16.	*Vertigo	None	Slight	Moderate	Severe
17.	**Visual flashbacks	None	Slight	Moderate	Severe
18.	Faintness	None	Slight	Moderate	Severe
19.	Aware of breathing	None	Slight	Moderate	Severe
20.	***Stomach awareness	None	Slight	Moderate	Severe
21.	Loss of appetite	None	Slight	Moderate	Severe
22.	Increased appetite	None	Slight	Moderate	Severe
23.	Desire to move bowels	None	Slight	Moderate	Severe
24.	Confusion	None	Slight	Moderate	Severe
25.	Burping	None	Slight	Moderate	Severe
26.	Vomiting	None	Slight	Moderate	Severe
27.	Other				

* Vertigo is experienced as loss of orientation with respect to vertical upright.

** Visual illusion of movement or false sensations of movement, when not in the simulator, car, or aircraft.

*** Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

STOP HERE! The test director will tell you when to continue.

POST 00 Minutes Exposure Symptom Checklist

Instructions: Circle how much each symptom below is affecting you right now.

#	Symptom	Severity			
1.	General discomfort	None	Slight	Moderate	Severe
2.	Fatigue	None	Slight	Moderate	Severe
3.	Boredom	None	Slight	Moderate	Severe
4.	Drowsiness	None	Slight	Moderate	Severe
5.	Headache	None	Slight	Moderate	Severe
6.	Eye strain	None	Slight	Moderate	Severe
7.	Difficulty focusing	None	Slight	Moderate	Severe
8a.	Salivation increased	None	Slight	Moderate	Severe
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11.	Difficulty concentrating	None	Slight	Moderate	Severe
12.	Mental depression	None	Slight	Moderate	Severe
13.	"Fullness of the head"	None	Slight	Moderate	Severe
14.	Blurred Vision	None	Slight	Moderate	Severe
15a.	Dizziness with eyes open	None	Slight	Moderate	Severe
15b.	Dizziness with eyes closed	None	Slight	Moderate	Severe
16.	*Vertigo	None	Slight	Moderate	Severe
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18.	Faintness	None	Slight	Moderate	Severe
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21.	Loss of appetite	None	Slight	Moderate	Severe
22.	Increased appetite	None	Slight	Moderate	Severe
23.	Desire to move bowels	None	Slight	Moderate	Severe
24.	Confusion	None	Slight	Moderate	Severe
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27.	Other				

* Vertigo is experienced as loss of orientation with respect to vertical upright.

** Visual illusion of movement or false sensations of movement, when not in the simulator, car or aircraft.

*** Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

POST-EXPOSURE INFORMATION

- While in the virtual environment, did you get the feeling of motion (i.e., did you experience a compelling sensation of self motion as though you were actually moving)? (*Circle one*)

YES

NO

SOMEWHAT

- On a scale of 1 (POOR) to 10 (EXCELLENT) rate your performance in the virtual environment:
- Did any unusual events occur during your exposure? (*Circle one*) YES NO
 - If YES, please describe

APPENDIX C: SYMPTOM CHECKLIST

APPENDIX C: SYMPTOM CHECKLIST

Client ID# _____ Date: _____

(ASRS-1.1) Symptom Checklist Please answer the questions below, rating yourself on each of the criteria shown using the scale on the right side of the page. As you answer each question, circle the correct number that best describes how you have felt and conducted yourself over the past 6 months. Please give this completed questionnaire to your healthcare professional to discuss during today's appointment. 0=Never 1=Rarely 2=Sometimes 3=Often 4=Very Often		0=Never	1=Rarely	2=Sometimes	3=Often	4=Very Often
1.	How often do you make careless mistakes when you have to work on a boring or difficult project?	0	1	2	3	4
2.	How often do you have difficulty keeping your attention when you are doing boring or repetitive work?	0	1	2	3	4
3.	How often do you have difficulty concentrating on what people say to you, even when they are speaking to you directly?	0	1	2	3	4
4.	How often do you have trouble wrapping up the final details of a project, once the challenging parts have been done?	0	1	2	3	4
5.	How often do you have difficulty getting things in order when you have to do a task that requires organization?	0	1	2	3	4
6.	When you have a task that requires a lot of thought, how often do you avoid or delay getting started?	0	1	2	3	4
7.	How often do you misplace or have difficulty finding things at home or at work?	0	1	2	3	4
8.	How often are you distracted by activity or noise around you?	0	1	2	3	4
9.	How often do you have problems remembering appointments or obligations?	0	1	2	3	4
10.	How often do you fidget or squirm with your hands or feet when you have to sit down for a long time?	0	1	2	3	4
11.	How often do you leave your seat in meetings or other situations in which you are expected to remain seated?	0	1	2	3	4
12.	How often do you feel restless or fidgety?	0	1	2	3	4
13.	How often do you have difficulty unwinding and relaxing when you have time to yourself?	0	1	2	3	4
14.	How often do you feel overly active and compelled to do things, like you were driven by a motor?	0	1	2	3	4
15.	How often do you find yourself talking too much when you are in social situations?	0	1	2	3	4
16.	When you're in a conversation, how often do you find yourself finishing the sentences of the people you are talking to, before they can finish them themselves?	0	1	2	3	4
17.	How often do you have difficulty waiting your turn in situations when turn taking is required?	0	1	2	3	4
18.	How often do you interrupt others when they are busy?	0	1	2	3	4
The ASRS-v1.1 Symptom Checklist was developed in conjunction with the World Health Organization (WHO), and the Workgroup that included the following team of psychiatrists and researchers: 1) Lenard Adler, MD, Associate Professor of Psychiatry and Neurology, New York University Medical School 2) Ronald C. Kessler, PhD, Professor, Department of Health Care Policy, Harvard Medical School and 3) Thomas Spencer, MD, Associate Professor of Psychiatry, Harvard Medical School. © 2004 World Health Organization						

APPENDIX D: DEMOGRAPHICS QUESTIONNAIRE

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Demographics Questionnaire

Please answer the following questions to the best of your ability by filling in the blank.

1. What is your age? _____
2. What is your sex (Male/Female)? _____
3. What is your ethnicity? _____
4. How many hours do you drive in a typical week? _____
5. How many years have you been able to drive legally? _____
6. Are you currently taking any prescribed medications for ADHD (Yes/No)? _____

APPENDIX E: DRIVING HABITS QUESTIONNAIRE

APPENDIX E: DRIVING HABITS QUESTIONNAIRE

Participant #: _____

Driving Habits Questionnaire

Please complete the following questionnaire by filling in the blanks or circling the appropriate answers for each item. If you should have any questions, please ask the researcher for assistance.

Date: _____
Sex: Male Female
Do you currently own a valid driver's license? Yes No
Are there any restrictions on your driver's license? Yes No If Yes, please specify: _____

1. What is your primary language? _____
2. Starting with the first grade, how many years of schooling have you completed?
_____ years of schooling.
3. Do you currently drive? Yes No
4. Are you the primary household driver? Yes No
5. Do you wear glasses or contacts when you drive? Yes No
6. Which way to you prefer to get around? (Please circle one)
 - a. I prefer to drive myself.
 - b. I prefer to have someone else drive me.
 - c. I prefer to use public transportation or a taxi.
7. When compared to the general flow of traffic, do you drive:
 - a. Much faster
 - b. Somewhat faster
 - c. About the same
 - d. Somewhat slower
 - e. Much slower
8. Over the past year, has anyone suggested that you limit your driving or stop driving? Yes No
 - a. If Yes, for what reason? _____
9. How would you rate the quality of your driving? (Please circle one)

Excellent Good Average Fair Poor

10. In an average week, how many days to you drive? _____ days per week
11. Over the past year, how many crashes have you been involved in while you were driving? _____ Crashes
12. Over the past year, how many times have you been pulled over by the police, whether or not you received a ticket? _____ Times
13. In the past five years, how many traffic tickets (other than parking tickets) have you received, whether or not you were at fault? _____ Tickets
14. Have you fallen within the last 6 months? Yes No
15. Have you fallen within the last 12 months? Yes No
16. Do you currently have any visual conditions/diseases that might potentially impair your driving ability? Yes No
- a. If so, what visual conditions do you have? _____
17. Do you currently have any neurological conditions/diseases that might potentially impair your driving ability?
- a. If so, what neurological conditions do you have? _____
18. Do you currently have any mobility conditions that might potentially impair your driving ability?
- a. If so, what mobility conditions do you have? _____

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